

III. Environment

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A succinct summary of the papers presented in the environment session is that, while the papers did not break any new ground in remote-sensing technology, they demonstrated a growing awareness and application of the technology in the field. This status is heartening. The fundamental need is recognition of the value, the efficiency, and the cost-saving advantages of the remote-sensing tools in solving environmental problems. With more recognition and with more users applying even the most fundamental techniques, technological advances will result.

The term "environment" as used in this symposium is too generic. Most of the papers in all the sessions had environmental aspects. With the advent of "land use" as a local, state, and Federal regulatory concern, however, the term environment is tending to be restricted to local, state, and Federal environmental quality *enforcement* considerations. Effective enforcement of environmental regulations requires comprehensive data bases and efficient monitoring. Both needs are potentially well served, and in some instances exclusively served, by remote-sensing techniques.

Those attending the symposium who were concerned with that more specific consideration of "environment" did well to choose from among the total offering of papers. It is recommended that selection of reports and papers for reading should be based on individual titles and not restricted to the environment session alone. For example, several papers dealing with river water quality were presented under the session heading "Water Resources."

This summary attempts to capture some of the key points of the papers presented and their broad significance, and to project their future application, problems, and payoffs. The discussion is based on the four general headings used for the symposium presentations.

WILDLIFE HABITAT AND LIFE SCIENCES

The urbanization of society increasingly encroaches on remaining wildlife habitats. To simply designate areas as preserves for such wildlife is not sufficient (E-1, vol. I-A). Wildlife species depend not only on sufficient space but on specific combinations of soil, water, vegetation, and other elements providing the necessary ecology.

The investigators produced 2 classification analyses in Travis County, Texas, of land and water cover, 10 resulting classes of which will be turned into base maps drawn from Landsat and other imagery. These maps will be used by biologists to begin the job of delineating species management units and by wildlife managers to apply management treatment necessary to produce sustained yields of wildlife resources. Such mapping of terrain suitable for wildlife species offers great potential for preserving and conserving biota, including those considered to be actually or potentially endangered by the continued encroachments of man.

The opposite situation, particularly that in which insect infestations are harmful to man, was considered in two papers. Although these papers dealt with eradication of the screwworm (E-2, vol. I-A) and the saltmarsh mosquito (E-3, vol. I-A), the applications of remote sensing to such work are broad enough to apply to most, if not all, infestation controls.

The screwworm, an agricultural pest, breeds principally in Mexico and affects North American livestock across the border. It can be eliminated by distributing sterile flies in the breeding grounds from aircraft. The governments of Mexico and the United States work jointly on this project.

Once the ecology of a screwworm, or other species, is understood, a mathematical model of its population dynamics can be built. Through remote sensing, its breeding grounds can be identified and monitored.

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Because screwworm infestations are largely determined by weather conditions, the National Oceanic and Atmospheric Administration ITOS satellites help delineate areas of screwworm activity at any given time. Satellite data can indicate not only where but when to combat insect infestations.

The paper on saltmarsh mosquitoes deals specifically with identifying the breeding grounds of this creator of nuisance and health problems throughout the U.S. coastal areas. It became clear in this presentation that the ecological relationships of the mosquito to particular vegetation and to flooding and exposure to saltwater in the marsh areas are being understood through remote-sensing outputs. Once these relationships are known, programs of control and abatement can be intelligently applied. Experience suggests that without such data, attempts at eradication are likely to destroy or harm other biota essential to the marshland environment.

The final paper in this section dealt with predicting human health levels using remote-sensing data (E-4, vol. I-A). Identifying incidence of mortality and of tuberculosis, hepatitis, and other human diseases in urban areas by aerial low-level color photography can seem preposterous. The potential, however, becomes clear when one recognizes the relationships of health levels to poverty and population density. The selection of block groupings having common characteristics in an urban community and the determination of the various health factors present by means of a ground census provide the basis for expanding that survey from the air to cover the entire urban area. Aerial photography reveals not only the density of population per urban block but such health-influencing factors as the amount of foliage and lawn and the presence of paved streets, gutters, and litter.

Very good correlations between ground census data and aerial data were reported. There appears to be much more work to come on this project to verify relationships of disease and mortality through both ground and aerial census data, but the hope for new advancements in the control and reduction of disease in urban environments is renewed by this effort.

STRIP MINING

Papers on the use of remote sensing for identification and control of strip mining summarized the state of the art in this area. One group applied Skylab and aircraft imagery as well as Landsat imagery to define strip-mine problems (E-6, vol. I-A). The focus here included

reclamation assessment; that is, the extent of seedling and grass growth and survival. Extendable digital techniques for large area coverage were used in a study (E-7, vol. I-A) demonstrating the feasibility of strip-mine monitoring to within 5 acres (2 hectares) with an average accuracy of classification greater than 93 percent.

To identify strip-mine locations, size, and environmental impact is fundamental. Multispectral analysis of satellite digital data is a useful monitoring technique in validating mining reports, in locating abandoned or unvegetated mines, and in assessing reclamation costs and requirements. Use of this technique also enables the identification and location of acid spoil and acid mine drainage sources and of siltation sources and routes, the monitoring of underground mine fires and of burning refuse piles, and the classification of materials in mine refuse dumps. Thermal imagery data, not available from Landsat-1 and Landsat-2, would be a valuable supplement to delineate ground-water outflow, ponding on strip-mine benches, storm runoff, surface water flow, and acid mine drainage.

Common to all such operations are the remoteness and the lack of ready accessibility on land to monitoring and enforcement efforts for ensuring proper and adequate reclamation of land areas and prevention of water quality degradation. Some of the illustrations presented with the papers (notably E-6, vol. I-A) clearly indicated how quickly, easily, and economically the required operational and restoration controls can be monitored.

WATER QUALITY

The water quality section focused on turbidity, eutrophication, and pollution discharges in lakes. One paper (E-9, vol. I-A) demonstrated quantitative measurement of suspended solids by use of Landsat multispectral scanner reflectance levels. Investigators found a 67-percent confidence level in accuracies of 12 p/m over a 0- to 80-p/m range and 35 p/m over a 0- to 900-p/m range. Correlation involved relating 16 separate Landsat passes with 170 water samples from 3 Kansas reservoirs during a period of 13 months.

Turbidity in lakes and streams minimizes the multiple-use functions of those water bodies. At known levels of turbidity, fish cannot spawn and cannot feed themselves. Fishermen catch little or nothing; swimmers avoid the water; and boaters and visitors to the shoreline find the lake or stream unattractive. Public and private commercial and recreational interests count resulting losses in dollars. Thus, monitoring and control of lake and stream turbidity is essential.

In one use of remote sensing in this area, Landsat data have helped determine valid reservoir sampling stations (E-10, vol. I-A). Landsat data help monitor reservoir areas not accessible by land or water and provide Secchi depth measurements in those inaccessible areas. The value of Landsat data in accurately monitoring land use changes and in predicting population shifts in reservoir (and natural lake) areas was also reported. This application is potentially significant in determining lake eutrophication (E-11, vol. I-A).

Eutrophication is a normally slow aging process in which a lake becomes so rich in nutritive compounds that algae and other microscopic plant life become superabundant and ultimately choke the lake and cause it to dry up. The process is accelerated by human activities in the vicinity of the lake, in fact, by the mere presence of humans. Using the Landsat multispectral scanner, investigators have located lakes and classified them in terms of the magnitude of nutrient growth and type on a eutrophic-oligotrophic scale.

In similar work (E-12, vol. I-A), a computer classification has been developed of the trophic status of the more than 3000 inland lakes of Wisconsin larger than 20 acres. Furthermore, researchers have been able to distinguish the difference between silt, tannin, and algae lakes from the Landsat imagery. Typically, costs were of great concern and available funds quite limited. "Overall," say the authors, "about \$4000 of computer time and \$6000 for operator salaries were required to obtain data for the 3000 lakes."

One paper (E-13, vol. I-A) reported not only on lake classification by biological condition of the water but on detection and quantification of sewage effluents outside Copenhagen, Denmark, in the Oresund. Lakes can be classified, using the Landsat multispectral scanner, by measuring the density of registered gray tones produced on bands 4 and 5. Good correlations with Secchi disk transparency readings were found. The result is a measure of lake transparencies and, indirectly, a relative measure of water turbidity and of algae and plankton content. Band 5 also appears to be useful in identifying water pollution. Landsat imagery showed surfacing of escaping sewage well off the shores of Copenhagen, the direction of its flow, and the extent of dispersion. Such conditions presumably would remain undetected without these remote-sensing techniques.

WETLANDS AND GENERAL ENVIRONMENT

The final section, on wetlands and general environment, featured the more dynamic papers in terms

of findings and potential applications. One paper (E-14, vol. I-A) compared the usefulness of Landsat-1 and Skylab data in coastal wetland mapping. Color photography from low-altitude aircraft, although high in accuracy, was found to be expensive, time consuming, and limited in scope of coverage. Landsat and Skylab data did not have these disadvantages. Using Landsat data, the team was able to distinguish between three classes of coastal wetland; Skylab data permitted a more detailed system consisting of five classes. Landsat data could not be used to delineate freshwater marshes; Skylab data could. In addition, drainage patterns could be mapped in more detail using Skylab data.

This report was particularly impressive in identifying the large amount of monitoring information available through remote sensing by satellite. Landsat data can be used to identify and monitor damming and river flow diversion, dredge and fill operations, lagooning for waterside homes, and highway construction. Skylab data have been used to identify dredging, spoil disposal, and mosquito ditching operations, all of which materially degrade wetlands. Similarly, a paper on the Green Swamp in central Florida (E-15, vol. I-A) showed how Skylab data were used to produce automatic mapping of a nine-category and three-category land-water cover map used in interpreting hydrologic conditions.

The goal of one investigator was to specify a practical procedure for the uniform mapping and monitoring of natural ecosystems and environmental complexes using the full range of satellite remote-sensing techniques (E-16, vol. I-A). He provides a comprehensive outline of his methodology, his findings, and the resulting procedure, which he considers operational.

Although most of the papers demonstrated how information necessary for decisionmaking could be collected through remote-sensing techniques, none more graphically pointed to ultimate decisions made as a result of remote sensing than a paper presented on applications in Kansas (E-17, vol. I-A). Among other things, these applications of remote sensing have led to the completion of an interstate highway and the cancellation of construction plans for a large reservoir, as well as to zoning changes around a smaller reservoir. This paper also discussed applications leading to expansion of irrigation programs in Kansas, and the incorporation of remote-sensing techniques into data acquisition methods used in Kansas City. Such urban applications include housing censuses, environmental impact measurements, and civil defense-disaster relief plans.

The paper concludes with the importance of such remote-sensing techniques as an added data source to state and local government officials. "As with the

introduction of any new technology," the authors say, "a measure of resistance is encountered in convincing officials to adopt remote sensing. Rapidly rising costs of alternative data collection systems, however, are stimulating many officials to examine the technology...."

Remote-sensing applications in the inventory and analysis of environmental problems were also considered (E-18, vol. I-A). Under the Federal Water Pollution Control Act, point sources of water pollution have been subjected to compliance control and have required permits for the last few years. Point sources are, in effect, specific, identifiable, single points of effluent discharge. The Federal act further requires subjecting nonpoint sources, such as runoff from animal feedlots, to controls. Nonpoint sources are much more difficult to identify and inventory. The Environmental Protection Agency (EPA), with NASA high-altitude aircraft support, is using remote sensing to develop such inventories. The EPA is also identifying stresses on ecosystems resulting from manmade changes to the environment.

THE VIEW AHEAD

The development of data bases, the collection of data, and the monitoring in the environmental field ultimately depend on budget allocations, which, apart from a few exceptions in the private sector, are inevitably tied to political decisions. Traditionally, such research, basic or applied, has had little political "sell" for elected officials; support for such programs has offered little with which to make favorable impressions on a political constituency presumed to want results rather than exotic collections of data that, they are told, can lead to desired results. Therefore, in budget-trimming exercises on environmental programs, the first cuts are usually made on items labeled research, data collection, or monitoring.

Strong signs that this situation is changing are evident. As environmental statutes, rules, and regulations increasingly limit individual, commercial, industrial, and governmental options — particularly in construction and production — environmental requirements are being challenged by such statements as "Prove the need for these requirements" and "Justify these controls." Too often, the answer is that although environmental problems have been identified, the lack of specific background data on the one hand prevents enforcement specifically geared to the need, and the lack of adequate monitoring on the other hand prevents effective and equitable enforcement.

Another major sign of change is the increasing disenchantment with essentially negative results produced by environmental control programs. The public is constantly being told what it cannot do in a specific locale; it is not told where proposed activities are environmentally acceptable. In the present economic climate, few communities will continue to tolerate environmental bans of proposed industrial developments unless suitable alternative sites can be offered.

Another impetus is the demand for better and faster response to large-scale crises: floods, development booms, energy shortages, unemployment, and other economic shortfalls. The demands for data become immediate, and the data must be in a form quickly usable and identifiable. Existing satellite and aircraft remote-sensing techniques offer help for these increasingly recognized needs, but remote sensing must be sold to guardians of the public purse in terms of results, of accuracy, of time savings, and of cost in comparison with existing ground collection efforts and efficiency.

An undercurrent of the symposium was the question of who should be providing what services. In the environmental field, the problem can be simply described: A Federal law requires that nonpoint water pollution sources be identified and controlled and assigns the EPA to the task. The EPA, in turn, seeks to get the states and local and regional governmental agencies to implement the law. Would it not be more sensible for EPA, itself, to provide the base data and to monitor, using standardized remote-sensing techniques and reporting, rather than to fund individual nonpoint source projects that operate with inevitably incomplete ground data exclusively? The question is one of efficient and effective use of national resources. Although it is clearly evident that many remote-sensing applications are of local and regional concern and should be so funded, delegating nationwide concerns to the smaller governmental entities for implementation when nationwide solutions exist calls for reconsideration.

The final paper of the environment session (E-18, vol. I-A) raised the question of using remotely sensed data in court. Use of such data in courts certainly will become common practice soon. Environmental laws, both Federal and state, have provided the public with a complete array of legal tools to challenge both permissive and restrictive environmental actions. The burden of proof in contested case hearings and suits is essentially on the governmental regulatory bodies. Remote sensing opens the door to an entirely new body of evidence in such cases. Remote-sensing data and data interpreters can expect to be called to court in a variety

of environmental cases, particularly those involving alleged violations of National Pollution Discharge Emission System permits.

The symposium revealed an almost infinite amount of data potential for application to recognized environmental problems. State and Federal leadership is needed to solve this problem of selectivity and of setting priorities in data acquisition and use.

Finally, there are large numbers of people, mostly government employees, in environmental and related fields whose work now and for the past many years has been to gather data on the ground. Remote sensing appears as a threat: a satellite photograph doing in moments what might represent years of work for them. Yet the symposium clearly established the continuing

need for such "ground truthing" work, especially to meet the verification needs of this still-new technology.

The simple fact remains that we have a tremendous need for information, which, if and when obtained, will prove to be too much to handle by conventional means. After all, the need is not for the data but for the information product. The requirement is to convert data from many sources to information products. Here, of course, the ultimate users must be involved, working with NASA and others to prepare outputs standardized for wider dissemination of information. Today, such standardized outputs might, for example, be maps showing lines of constant sediment concentrations. In the future, they may well be "environmental indices" essential to the coordinated effort toward mankind's need to preserve and protect the planet.